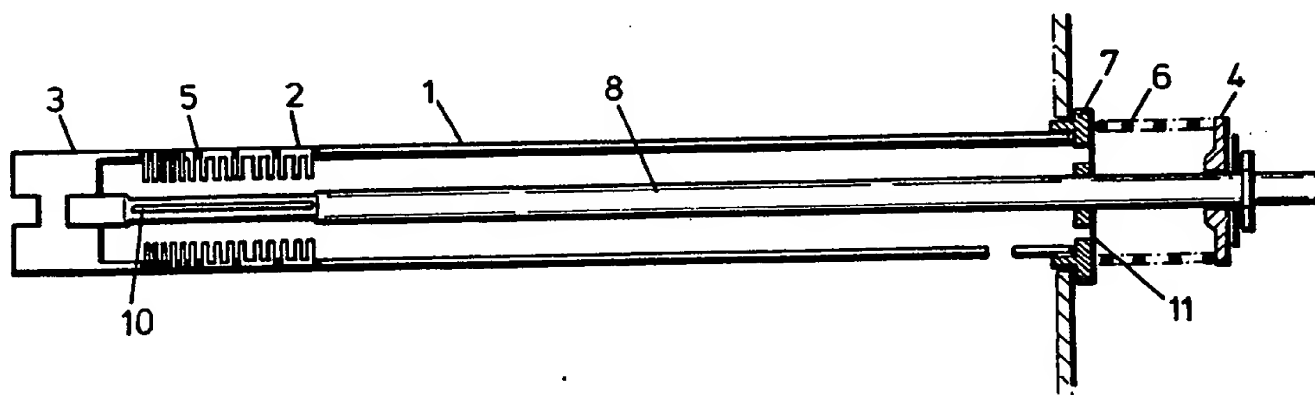




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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| <b>(51) International Patent Classification <sup>4</sup> :</b><br><br><b>G01N 17/00</b>   | <b>A1</b> | <b>(11) International Publication Number:</b> <b>WO 88/ 01052</b><br><br><b>(43) International Publication Date:</b> 11 February 1988 (11.02.88)   |
| <b>(21) International Application Number:</b> PCT/GB87/00500<br><b>(22) International Filing Date:</b> 15 July 1987 (15.07.87)<br><b>(31) Priority Application Number:</b> 8618237<br><b>(32) Priority Date:</b> 25 July 1986 (25.07.86)<br><b>(33) Priority Country:</b> GB<br><b>(71) Applicant (for all designated States except US):</b> THE UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY [GB/GB]; P.O. Box 88, Manchester, M60 1QD (GB).<br><b>(72) Inventors; and</b><br><b>(75) Inventors/Applicants (for US only) :</b> COX, William, Michael [GB/GB]; The First House, Spring Avenue, Gee Cross, Hyde, Cheshire SK14 5LT (GB). EDEN, David, Anthony [GB/GB]; 8 Brookdale Street, Failsworth, Manchester, M35 0HF (GB). FARRELL, David, Martin [GB/GB]; 17 Overdale Crescent, Flixton, Manchester, M31 3GR (GB). QUIRK, Graham, Peter [GB/GB]; 19 North Drive, Wesham, Kirkham, |           | Preston, PR4 3DJ (GB).<br><b>(74) Agent:</b> ALLMAN, Peter, John; Marks & Clerk, Suite 301, Sunlight House, Quay Street, Manchester M3 3JY (GB).<br><b>(81) Designated States:</b> AT, AT (European patent), AU, BB, BE (European patent), BG, BJ (OAPI patent), BR, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.<br><b>Published</b><br><i>With international search report.</i> |

**(54) Title:** CORROSION MONITORING PROBE**(57) Abstract**

A corrosion monitoring probe comprising a tubular assembly including a pair of end pieces (3, 4) between which are arranged a plurality of corrosion sensing members (2) separated by electrically insulating spacers (5) and a support member secured at its ends to the end pieces. Tension is applied to the support member (8) by springs (6) or resilient members to compress the corrosion sensing members (2) and spacers (5) together and to maintain the tension in the support member substantially constant in the event of differential thermal expansion of elements of the probe.

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CORROSION MONITORING PROBE

The present invention relates to a corrosion monitoring probe and in particular to a corrosion monitoring probe for sensing corrosion conditions to which a tubular metallic element is exposed.

There are various techniques for monitoring the rate at which metallic components corrode. For example electrochemical corrosion can be monitored by techniques of the type described in U.S. Patent Specification No. 4,575,678. Alternatively corrosion may be monitored by measuring the weight loss due to corrosion of metallic members exposed to the corrosion conditions. In many applications it is relatively easy to support the corrosion sensing members in a wall of the vessel or pipe the corrosion of which is to be monitored. There are certain situations however where it is very difficult to mount the corrosion sensing members such that the corrosion conditions to which they are exposed are truly representative of the corrosion conditions to which the surfaces being monitored are exposed. For example in heat exchangers relatively small bore pipes are often provided as the thermal interface between a heating medium such as combustion gases and a medium to be heated such as water. In such conditions the pipes are not only exposed to often severe corrosion but also must withstand large temperature changes occurring relatively rapidly.

If a corrosion probe is used which is not of the same size and material as the pipes the corrosion of which is to be monitored the corrosion of the sensing members cannot be relied upon as an accurate representation of the corrosion to which the pipes are in fact exposed. Ideally the corrosion probes

should be mounted in a structure of the same dimensions as the pipes themselves and this causes considerable difficulties. Attempts have been made to produce such probes but the results attained with the prior art probes have been far from satisfactory. It appears that these unsatisfactory results are caused by the different thermal expansion characteristics of the probe structure as compared with the pipes the corrosion of which is to be monitored.

It is an object of the present invention to obviate or mitigate the above problems.

According to the present invention there is provided a corrosion monitoring probe comprising a tubular assembly including a pair of end pieces between which are arranged a plurality of corrosion sensing members separated by electrically insulating spacers, a support member secured at its ends to the end pieces, and means for applying tension to the support member to compress the corrosion sensing members and spacers together, the tension applying means maintaining the tension in the support member substantially constant in the event of differential thermal expansion of elements of the probe.

The support may be in the form of a rod or tube extending axially along the tubular assembly or alternatively in the form of a tube through which the tubular assembly extends. Tension may be applied by for example a compression spring or resilient members forming a part of the tubular assembly. The resilient members may be for example dished washers such as washers of the type normally referred to as "belville" washers or simple washers of a resilient polymeric material.

Embodiments of the present invention will now be

described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a schematic sectional view through an electrochemical corrosion probe in accordance with the invention;

Fig. 2 is an enlarged illustration of a portion of the probe of Fig. 1;

Figs. 3 & 4 are plan views of an insulating spacing washer and a corrosion sensing electrode respectively of the probe of Fig. 1;

Fig. 5 is a side view of the electrode of Fig. 4; and

Fig. 6 is a schematic sectional view of a weight loss corrosion probe in accordance with the invention.

Referring to Figs. 1 to 5, the illustrated probe comprises a tubular assembly comprising a main tube 1, eight corrosion sensing electrodes in the form of metallic rings 2 of for example aluminium, a first end piece 3, a second end piece 4, a series of insulating spacing washers 5 of for example silicon, and a compression spring 6 arranged between the end piece 4 and a flange 7 welded to the end of the tube 1.

A tubular tension member 8 extends axially through the tubular assembly and is secured to the end piece 3 and bears against the end piece 4 so as to apply tension to the tubular assembly. Cooling air can be introduced through the end 9 of the tension member, the cooling air issuing through slots 10 and returning around the outside of the tension member to escape through apertures 11.

The compression forces on the electrodes 2 and the spacers 5 is determined by the strength of the compression spring 6 and accordingly this compression does not alter significantly even if the elements

forming the probe are subjected to thermal expansions and contractions as a result of changes in the temperature to which the probe is exposed. With this structure it has been found that corrosion measurements taken by monitoring the electrochemical corrosion of the electrodes 2 are truly representative of the corrosion which occurs in a pipe manufactured from the same material as the electrodes 2 and having the same outside diameter. If the spring 6 was replaced by a rigid tube the resulting corrosion measurements are inaccurate. It is thought that the provision of the compression spring 6 provides improved accuracy because crevicing conditions are maintained substantially constant.

Thus a relatively easy to manufacture and assemble probe can be used in a wide variety of applications where a tubular form for the probe is required.

It will be appreciated that the tension member 8 could be in the form of a tube arranged outside the tubular assembly rather than inside the tubular assembly as illustrated in Fig. 1.

Referring now to Fig. 6, the illustrated probe comprises a plurality of coupons 12 separated by spacers 13. A tubular tension member 14 and compression spring 15 provide the necessary stable compression of the various components. Cooling air may be introduced through the tension member 14 to issue from slots 16 and return via apertures 17 in the spacers 13. The spacers 13 may be fabricated from PTFE.

It will be appreciated that any convenient means may be provided for applying a substantially constant tension to the tension member 14. For example the compression springs could be replaced by resilient

members of for example polymeric material or by one or more dished washers. The means for providing the necessary tension could be incorporated in the tubular structure rather than positioned at one end thereof.

CLAIMS:

1. A corrosion monitoring probe comprising a tubular assembly including a pair of end pieces between which are arranged a plurality of corrosion sensing members separated by electrically insulating spacers, a support member secured at its ends to the end pieces, and means for applying tension to the support member to compress the corrosion sensing members and spacers together, the tension applying means maintaining the tension in the support member substantially constant in the event of differential thermal expansion of elements of the probe.

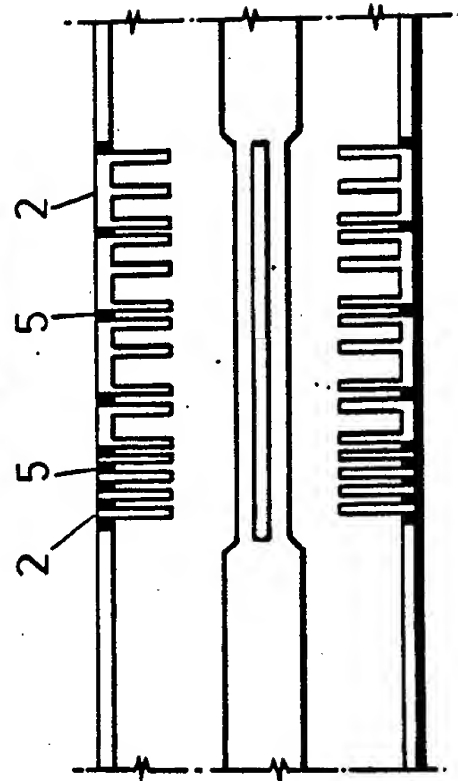
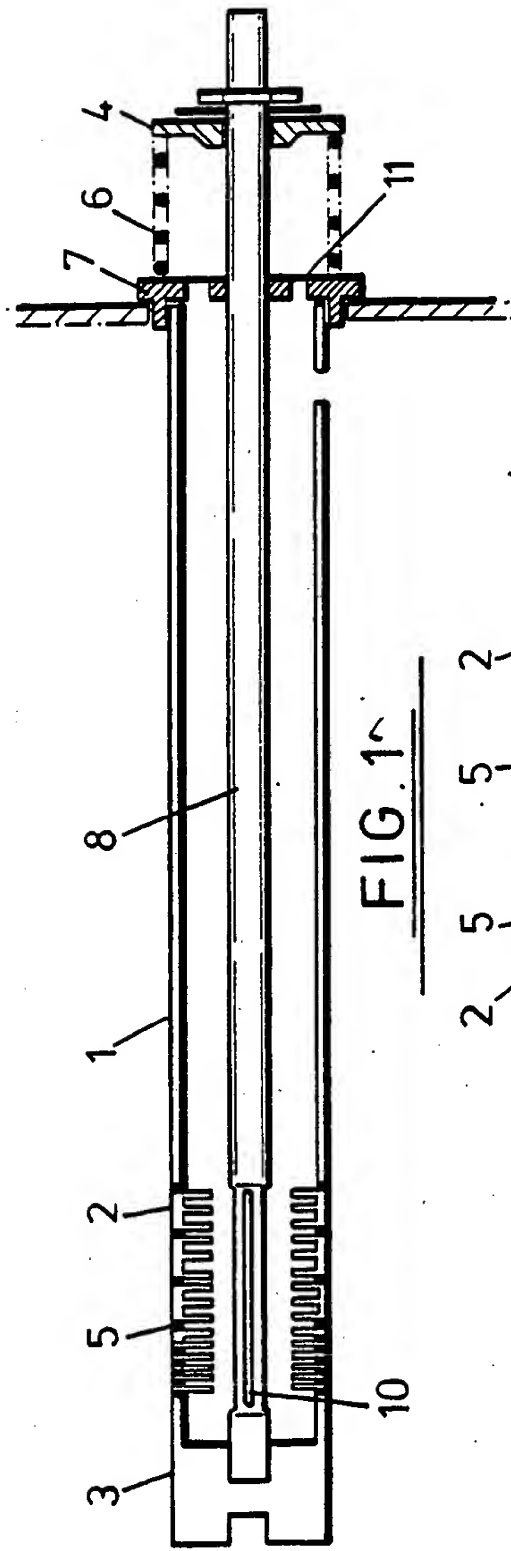
2. A corrosion monitoring probe according to claim 1, wherein the support member is an elongate member extending axially along the tubular assembly.

3. A corrosion monitoring probe according to claim 1, wherein the support member is in the form of a tube through which the tubular assembly extends.

4. A corrosion monitoring probe according to claim 1, 2 or 3, wherein the tension applying means comprises a compression spring forming a part of the tubular assembly.

5. A corrosion monitoring probe according to claim 1, 2 or 3, wherein the tension applying means comprises resilient members forming a part of the tubular assembly.





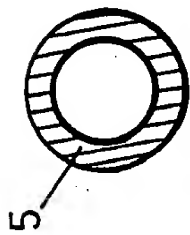


FIG. 3

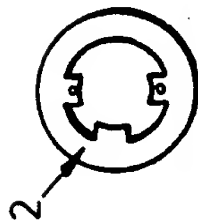


FIG. 4

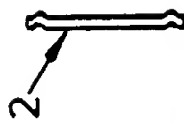


FIG. 5

16 12 13 17 14

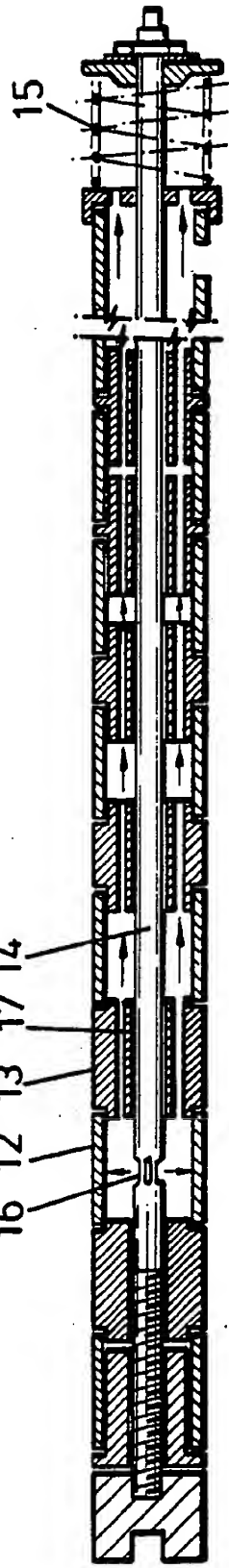


FIG. 6

## INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00500

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) \*

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC<sup>4</sup>: G 01 N 17/00

## II. FIELDS SEARCHED

Minimum Documentation Searched \*

Classification System

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IPC<sup>4</sup> G 01 N 17/00Documentation Searched other than Minimum Documentation  
to the Extent that such Documents are Included in the Fields Searched \*

## III. DOCUMENTS CONSIDERED TO BE RELEVANT \*

| Category * | Citation of Document, ** with indication, where appropriate, of the relevant passages **                                       | Relevant to Claim No. ** |
|------------|--|--------------------------|
| X          | US, A, 3491012 (J.D. WINSLOW)<br>20 January 1970<br>see column 3, lines 11-42; figure 1<br>--                                  | 1,2,4                    |
| X          | US, A, 3504323 (J.J. MEANY) 31 March 1970<br>see column 2, line 47 - column 3,<br>line 75; figure 1<br>--                      | 1,3,5                    |
| A          | US, A, 2834858 (E. SCHASCHL) 13 May 1958<br>see column 3, lines 19-58<br>--  | 1                        |
| A          | EP, A, 0052388 (CISE-CENTRO INFORMAZIONI<br>STUDI ESPERIENZE) 26 May 1982<br>see page 6, line 10 - page 7, line<br>18<br>----- | 1                        |

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## IV. CERTIFICATION

Date of the Actual Completion of the International Search

16th October 1987

Date of Mailing of this International Search Report

1- 6 NOV 1987

International Searching Authority

EUROPEAN PATENT OFFICE

Signature of Authorized Officer

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This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 23/10/87

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| Patent document<br>cited in search<br>report | Publication<br>date | Patent family<br>member(s) | Publicatio<br>date |
|--|---------------------|----------------------------|--------------------|
| US-A- 3491012                                | 20/01/70            | None                       |                    |
| US-A- 3504323                                | 31/03/70            | None                       |                    |
| US-A- 2834858                                |                     | None                       |                    |
| EP-A- 0052388                                | 26/05/82            | US-A- 4426618              | 17/01/84           |

For more details about this annex :  
see Official Journal of the European Patent Office, No. 12/82